UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/820,692	03/30/2001	Ting Chien	015290-506	5245

7590 05/28/2003

Peter K. Skiff
BURNS, DOANE, SWECKER & MATHIS, L.L.P.
P.O. Box 1404
Alexandria, VA 22313-1404

EXAMINER	
CHEN, KIN CHAN	
ART UNIT	**PAPER NUMBER**
1765	17

DATE MAILED: 05/28/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)
	09/820,692	CHIEN ET AL.
	Examiner	Art Unit
	Kin-Chan Chen	1765

-- *The MAILING DATE of this communication appears on the cover sheet with the correspondence address* --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____ .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-25 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-25 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

Claim Rejections - 35 USC § 112

1. Claims 23-25 are rejected under 35 U.S.C. 112, first paragraph, as containing subject matter, which was not described in the specification.

In claim 23, " the etchant gas is hydrogen-free" is new matter.

In claim 24, "the etchant gas consists essentially of a hydrogen-free fluorocarbon gas, an oxygen-containing gas and optional carrier gas" is new matter because "consists essentially of" excludes other materials. The instantly claimed invention does not have this negative limitation in the disclosure.

In claim 25, "the etchant gas consists of a hydrogen-free fluorocarbon gas, an oxygen-containing gas and optional carrier gas" is new matter because "consists essentially of" excludes other materials. The instantly claimed invention does not have this negative limitation in the disclosure.

Claim Rejections - 35 USC § 103

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

3. Claims 1-5, 9-12, and 14-25 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hung et al. (US 6,174,451 B1) in view of Wang et al. (US 6,074,959).

Hung teaches a method of etching a dielectric layer (e.g., oxide layer) with selectivity to an underlying stop layer. A semiconductor substrate is supported in a plasma etch reactor. The substrate includes a dielectric layer (e.g., oxide layer) over a nitride stop layer (col. 2, lines 24-31; Figs 1 and 2), e.g., SAC structure. An etchant gas may be supplied to the plasma etch chamber. Etching openings may be performed in the dielectric layer (Fig. 1) by energizing the etchant gas into a plasma state. The etchant gas may comprise a hydrogen-free fluorocarbon gas represented by C_xF_y gas wherein $y/x < 1.5$ (such as C_4F_6) and carrier gas (such as Ar). See col. 7, TABLE 1, first etch recipe and col. 7, lines 33-56. The main etch (using C_4F_6) with no CH_2F_2 may be used to etch **the entire oxide layer** (col.10, lines 21-24).

Unlike the claimed invention, Hung does not teach that an oxygen-containing gas may be incorporated in the etchant gas for oxide layer (dielectric layer) etching. In a method of plasma etching openings of dielectric layer with high selectivity of dielectric to the silicon nitride, Wang teaches that fluorocarbon may be used (Fig 1; col. 9, lines 42-47). The process may be modified by the addition of carbon monoxide, nitrogen, or oxygen, all of which are known to enhance selectivity and increase the etch stop margin (col. 10, lines 23-26). Hence, it would have been obvious to one with ordinary skill in the art to modify the etchant gas of Hung by adding oxygen as taught by Wang because Wang teaches that to do so will enhance selectivity and increase the etch stop margin.

As to dependent claim 2, Hung teaches these structures (col. 11, lines 11-30).

As to dependent claim 3, Hung teaches that the stop layer may be silicon nitride and the etch rate selectivity of the dielectric to the silicon nitride is at least 10 (col. 7, lines 50-56).

As to dependent claim 4, Hung teaches doped or undoped silicon oxide layer (col. 1, lines 27-33).

As to dependent claim 5, Hung teaches the limitation (col. 3, lines 12 and 18).

As to dependent claim 9, 10, 16, and 17, the combined prior art (Hung and Wang) teaches C_xF_y gas (such as C_4F_6) and oxygen. Hung and Wang are relied on for the same reasons as stated, supra. The combined prior art does not teach the ratio of flow rates of the said fluorocarbon to oxygen. The instant claims differ from the prior art by teaching the ratio of flow rates of the said fluorocarbon to oxygen (such as 0.5:1 to 5:1 in claims 9 and 16; 1:1 to 2:1 in claims 10 and 17). However, same is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable ratio of flow rates through routine experimentation in the combined prior art in order to produce the best etched product achievable.

As to dependent claim 11, Hung (col. 8, Table 2, main etch) teaches that pressure in the plasma etch reactor may be 10 mTorr and temperature of the substrate support (e.g., cathode temperature) may be 15 ^{0}C, which is within the claimed range.

Dependent claim 12 differs from the combined prior art by specifying the different process parameters (pressure of reactor and temperature of the substrate support). However, Hung teaches that the process parameters may vary and dependent on different commercially available plasma reactors (col. 11, lines 43-44).

Furthermore, same were known to be result-effective variables, it would have been obvious to one of ordinary skilled in the art to determine the optimum, operable range of process parameters (e.g., pressure of reactor and temperature of the substrate support) for different commercially available plasma reactors in the combined prior art in order to provide their art recognized advantages and produce an expected result.

As to dependent claim 14, Wang teaches that fluorocarbon may be used (Fig 1; col. 9, lines 42-47). The process may be modified by the addition of carbon monoxide (CO), which is known to enhance selectivity and increase the etch stop margin (col. 10, lines 23-26). Hence, it would have been obvious to one with ordinary skill in the art to modify the etchant gas of Hung by adding carbon monoxide as taught by Wang because Wang teaches that to do so will enhance selectivity and increase the etch stop margin. The combined prior art does not teach that the rate of 50 to 500 sccm CO may be supplied to the etch reactor. However, same is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable ratio through routine experimentation in the combined prior art in order to produce the best etched product achievable.

As to dependent claim 15, Hung teaches C_4F_6 (col. 7, line 4).

As to dependent claim 18, in order to complete the etching of the openings, keeping an amount of etchants (e.g., C_4F_6 and oxygen) sufficient to avoid etch stop is considered inherent in the method of combined Hung and Wang. Hung and Wang are relied on for the same reasons as stated, supra.

As to dependent claims 19-21, Hung teaches that the dielectric layer (oxide layer) may be BPSG (col. 1, lines 32-34) and the stop layer may comprise silicon nitride (col. 2, lines 29-30). The etch rate selectivity of the oxide layer (e.g., TEOS) to the corner portion of the silicon nitride may be 20 (col. 7, lines 51-56). The combined prior art (Hung and Wang) teaches C_xF_y gas (such as C_4F_6) and oxygen. Hung and Wang are relied on for the same reasons as stated, supra. The combined prior art does not teach the etch rate selectivity of the BPSG (or dielectric) to nitride (or stop layer) and the ratio of the flow rates of $O_2 : C_4F_6$. The instant claims differ from the prior art in the etch rate selectivity of the BPSG (or dielectric) to nitride (or the stop layer) (e.g., at least 15 in claim 19; greater than 30:1 in claim 21) and the flow rates having a ratio of $O_2 : C_4F_6$ (e.g., 0.5 to 1.2 in claim 20). However, the ratio of the flow rates of O_2 : fluorocarbon is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable flow rate ratio of O_2 to C_4F_6 through routine experimentation in the combined prior art in order to produce the best etched product achievable and desired etch rate selectivity.

As to dependent claims 22-23, Hung teaches that the main etch with no CH_2F_2 may be used to etch **the entire oxide layer** (col.10, lines 21-24), and it appears that the etchant for etching the entire oxide layer is hydrogen-free.

As to dependent claims 24 and 25, the combined prior art (Hung and Wang) teaches that etchant gas may include a hydrogen-free fluorocarbon gas represented by C_xF_y gas wherein $y/x < 1.5$ (such as C_4F_6), an oxygen containing gas and carrier gas (such as Ar), therefore, it would have been obvious to one with ordinary skill in the art to

have the etchant gas consists essentially of (or consist of) a hydrogen-free fluorocarbon gas represented by C_xF_y gas wherein y/x < 1.5 (such as C_4F_6), an oxygen containing gas and carrier gas (such as Ar).

4. Claims 6-8 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hung et al. (US 6,174,451 B1) and Wang et al. (US 6,074,959) as applied to claim 1 above, and further in view of Schmitt (US 6,228,438 B1).

The discussion of modified Hung and Wang from above is repeated here.

Hung teaches that his oxide etching process (with nitride stop layer) may use commercially available plasma reactors (col. 11, lines 43-44). Therefore, it would have been obvious to one with ordinary skill in the art to use popular commercial available plasma reactors. Schmitt is relied on only to teach one of the popular commercial available plasma reactors with dual frequency capacitively coupled plasma reactor including an upper showerhead electrode and a bottom electrode as claimed (see col. 1, line 15-17; col. 8, lines 1-12). Hence, it would have been obvious to one with ordinary skill in the art to use the popular commercial available plasma reactors as disclosed by Schmitt in the process of Hung and Wang in order to provide their art recognized advantages and produce an expected result.

As to dependent claims 7 and 8, Hung (col. 7, TABLE I, first etch recipe) teaches that the flow rates of 20 sccm C_4F_6 and 100 sccm Ar may be used, which is within the claimed range. Hung, Wang and Schmitt are relied on for the same reasons as stated, supra. The combined prior does not disclose the flow rate of oxygen (O_2) for the

process. However, same is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable flow rate of oxygen (O_2) for the process through routine experimentation in the combined prior art in order to produce the best-etched product achievable.

As to dependent claim 13, Hung, Wang and Schmitt are relied on for the same reasons as stated, supra. The combined prior art does not disclose the range of RF energy being supplied into the process. The instant claim differs from the combined prior art by specifying showerhead electrode and bottom electrode being supplied 0 to 3000 watts of RF energy. However, it is merely a matter of choice of engineering depending on product requirement. One skilled in the art at the time of the invention would have found it obvious to apply engineering practice to determine the range of RF energy suitable for the process and the specific product requirement in order to provide their art recognized advantages and produce the best-etched product achievable. It is noted that applicant did not traverse the aforementioned conventionality of features, which have been stated in the office action in Paper No.7.

5. Claims 1-5, 9-12, and 14-25 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kadomura (US 5,366,590) in view of Wang et al. (US 6,074,959).

Kadomura teaches a method of etching a dielectric layer) with selectivity to an underlying stop layer. A semiconductor substrate is supported in a plasma etch reactor. The substrate includes a dielectric layer (e.g., oxide layer) over a nitride stop layer. An etchant gas may be supplied to the plasma etch chamber. Etching openings may be

performed in the dielectric layer by energizing the etchant gas into a plasma state. The etchant gas may comprise a hydrogen-free fluorocarbon gas represented by C_xF_y gas wherein y/x < 1.5 (such as C_4F_6 or C_6F_6). See col. 4, lines 4-42 and col. 5 line 60 through col. 6, lines 46.

Unlike the claimed invention, Kadomura does not teach that an oxygen-containing gas may be incorporated in the etchant gas for oxide layer (dielectric layer) etching. In a method of plasma etching openings of dielectric layer with high selectivity of dielectric to the silicon nitride, Wang teaches that fluorocarbon may be used (Fig 1; col. 9, lines 42-47). The process may be modified by the addition of carbon monoxide, nitrogen, or oxygen, all of which are known to enhance selectivity and increase the etch stop margin (col. 10, lines 23-26). Hence, it would have been obvious to one with ordinary skill in the art to modify the etchant gas of Kadomura by adding oxygen as taught by Wang because Wang teaches that to do so will enhance selectivity and increase the etch stop margin.

As to dependent claim 9, 10, 16, and 17, the combined prior art (Kadomura and Wang) teaches C_xF_y gas and oxygen. Kadomura and Wang are relied on for the same reasons as stated, supra. The combined prior art does not teach the ratio of flow rates of the said fluorocarbon to oxygen. The instant claims differ from the prior art by teaching the ratio of flow rates of the said fluorocarbon to oxygen (such as 0.5:1 to 5:1 in claims 9 and 16; 1:1 to 2:1 in claims 10 and 17). However, same is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art

to determine the suitable ratio of flow rates through routine experimentation in the combined prior art in order to produce the best etched product achievable.

Dependent claims 11 and 12 differ from the combined prior art by specifying the different process parameters (such pressure of reactor and temperature of the substrate support). However, same were known to be result-effective variables, it would have been obvious to one of ordinary skilled in the art to determine the optimum, operable range of process parameters (e.g., pressure of reactor and temperature of the substrate support) for different commercially available plasma reactors in the combined prior art in order to provide their art recognized advantages and produce an expected result.

As to dependent claim 14, Wang teaches that fluorocarbon may be used (Fig 1; col. 9, lines 42-47). The process may be modified by the addition of carbon monoxide (CO), which is known to enhance selectivity and increase the etch stop margin (col. 10, lines 23-26). Hence, it would have been obvious to one with ordinary skill in the art to modify the etchant gas of Kadomura by adding carbon monoxide as taught by Wang because Wang teaches that to do so will enhance selectivity and increase the etch stop margin. The combined prior art does not teach that the rate of 50 to 500 sccm CO may be supplied to the etch reactor. However, same is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable ratio through routine experimentation in the combined prior art in order to produce the best etched product achievable.

As to dependent claim 18, in order to complete the etching of the openings, keeping an amount of etchants sufficient to avoid etch stop is considered inherent in the method of combined Kadomura and Wang. Kadomura and Wang are relied on for the same reasons as stated, supra.

As to dependent claims 19-21, It is well known in the art of semiconductor device fabrication that the dielectric layer (oxide layer) may be BPSG or silicon dioxide and etching characteristics are equivalent, the substitution of one for the other would have expected to provide similar result. The combined prior art teaches C_xF_y gas (such as C_4F_6 or C_4F_6) and oxygen. Kadomura and Wang are relied on for the same reasons as stated, supra. The combined prior art does not teach the etch rate selectivity of the BPSG (or dielectric) to nitride (or stop layer) and the ratio of the flow rates of $O_2 : C_4F_6$. The instant claims differ from the prior art in the etch rate selectivity of the BPSG (or dielectric) to nitride (or the stop layer) (e.g., at least 15 in claim 19; greater than 30:1 in claim 21) and the flow rates having a ratio of $O_2 : C_4F_6$ (e.g., 0.5 to 1.2 in claim 20). However, the ratio of the flow rates of O_2 : fluorocarbon is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable flow rate ratio of O_2 to C_4F_6 through routine experimentation in the combined prior art in order to produce the best etched product achievable and desired etch rate selectivity.

As to dependent claims 24 and 25, the combined prior art (Kadomura and Wang) teaches that etchant gas may include a hydrogen-free fluorocarbon gas represented by C_xF_y gas wherein $y/x < 1.5$ (such as C_6F_6), an oxygen containing gas and carrier gas,

therefore, it would have been obvious to one with ordinary skill in the art to have the etchant gas consists essentially of (or consist of) a hydrogen-free fluorocarbon gas represented by C_xF_y gas wherein $y/x < 1.5$ (such as C_6F_6), an oxygen containing gas and carrier gas.

6. Claims 6-8 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kadomura (US 5,366,590) and Wang et al. (US 6,074,959) as applied to claim 1 above, and further in view of Schmitt (US 6,228,438 B1).

The discussion of modified Kadomura and Wang from above is repeated here.

Kadomura teaches that his oxide etching process (with nitride stop layer) may use commercially available plasma reactors. Therefore, it would have been obvious to one with ordinary skill in the art to use popular commercial available plasma reactors. Schmitt is relied on only to teach one of the popular commercial available plasma reactors with dual frequency capacitively coupled plasma reactor including an upper showerhead electrode and a bottom electrode as claimed (see col. 1, line 15-17; col. 8, lines 1-12). Hence, it would have been obvious to one with ordinary skill in the art to use the popular commercial available plasma reactors as disclosed by Schmitt in the process of Kadomura and Wang in order to provide their art recognized advantages and produce an expected result.

The combined prior does not disclose the flow rate of oxygen (O_2) for the process. However, same is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable flow rate of oxygen

(O_2) for the process through routine experimentation in the combined prior art in order to produce the best-etched product achievable.

As to dependent claim 13, Kadomura, Wang and Schmitt are relied on for the same reasons as stated, supra. The combined prior art does not disclose the range of RF energy being supplied into the process. The instant claim differs from the combined prior art by specifying showerhead electrode and bottom electrode being supplied 0 to 3000 watts of RF energy. However, it is merely a matter of choice of engineering depending on product requirement. One skilled in the art at the time of the invention would have found it obvious to apply engineering practice to determine the range of RF energy suitable for the process and the specific product requirement in order to provide their art recognized advantages and produce the best-etched product achievable.

Response to Arguments

7. Applicant's arguments filed on June 28, 2002 have been fully considered but they are not persuasive.

Applicant has argued that Hung teaches away from using an oxygen-containing gas in etching a dielectric layer with selectivity to an underlying nitride. This is incorrect. Hung teaches etching oxide layer (e.g., dielectric), with nitride as a stop layer, using hydrogen-free fluorocarbon (e.g., C_4F_6). After oxide etching, nitride layer may be etched using CH_2F_2, Ar, and oxygen, and oxygen destroys any nitride selectivity because at this time Hung is etching nitride with different chemistry (e.g., CH_2F_2, a hydrogen-

containing fluorocarbon), it is irrelevant to previous etching of oxide overlying nitride stop layer using hydrogen-free fluorocarbon (e.g., C_4F_6). Furthermore, as stated in the office action, Wang teaches that the addition of carbon monoxide, nitrogen, or oxygen, all of which are known to enhance selectivity and increase the etch stop margin (col. 10, lines 23-26). Hence, it would have been obvious to one with ordinary skill in the art to modify the etchant gas of Hung by adding oxygen as taught by Wang because Wang teaches that to do so will enhance selectivity and increase the etch stop margin.

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Kin-Chan Chen whose telephone number is (703) 305-0222. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Benjamin Utech can be reached on (703) 308-3836. The fax phone numbers for the organization where this application or proceeding is assigned are (703) 872-9310 for regular communications and (703) 872-9311 for After Final communications. Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-2934.

K. C. Chen.

Kin-Chan Chen
PRIMARY EXAMINER
Group Art Unit 1765

May 21, 2003